Instrumentation Working Group, Proposed Instrument Concept Form

Autonomous Airborne Sun/Sky-Scanning Spectrometer

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_____Civil Service _____Contractor _x_ Cooperative Agreement BAER Institute

Names of collaborators or team members:

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Brief Description of Instrument / Technology:

Atmospheric aerosols play a crucial role in the Earth's radiation balance and may hold the key to combating global warming. However, more knowledge is needed about aerosol sources, distributions and properties. This requires continuous observations from satellites, networks of ground-based instruments, and dedicated field experiments. The existing Ames airborne sunphotometers have contributed significantly to such field experiments by making sunlight transmission measurements at 6 or 14 discrete wavelengths. An airborne instrument that measures a continuous spectrum of the direct solar beam and of the scattered sunlight as a function of angular distance from the Sun will deliver considerably more information on atmospheric aerosols and gases but does not currently exist. The envisioned instrument is targeted for autonomous operation on small or unmanned aircraft (see Fig. 1).

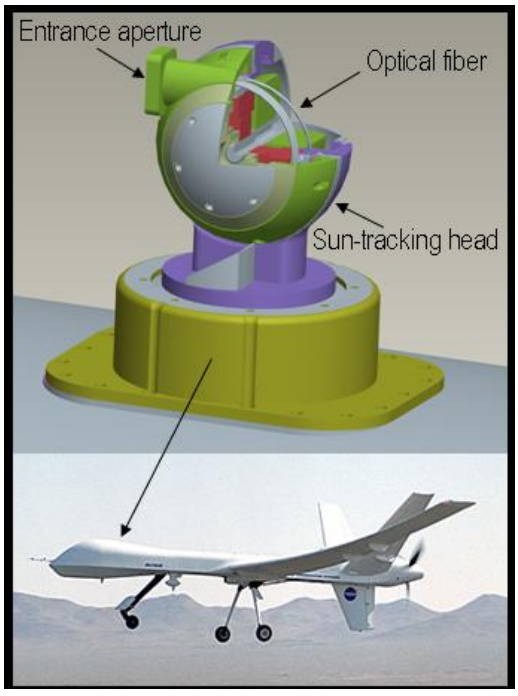

Fig. 1: Pro-E model of proposed Autonomous Airborne Sun/Sky-Scanning Spectrometer.

Anticipated application(s) &/or Funding Opportunities (NRA, AO, missions, etc.):

Operating sunphotometers aboard aircraft has proven to be a very valuable tool to extend the temporally continuous land-based point observations by ground-based sunphotometers to a larger geographical area that includes the oceans and the vertical dimension. NASA Ames has been the world leader in airborne sunphotometry since the first flights of the Ames 6-channel airborne sunphotometer (AATS-6) in 1985. A second, enhanced 14-channel unit, AATS-14, was completed in 1996. Both instruments have been flown in many campaigns focusing on atmospheric aerosol all over the world and have, to date, contributed to validating 11 satellite sensors.

The envisioned new instrument with its enhanced

capabilities will build on this heritage and will be in high demand for many future missions sponsored by NASA, NOAA, DOE, Navy, etc.

Relevance to ARC and Agency Strategic Goals, and Exploration Initiative:

Our team envisions building a smaller and lighter (compared to our current airborne sunphotometer) and fully autonomous instrument with increased observational capabilities targeted for small aircraft or UAVs. This is very much in line with the recent mandate from NASA HQ to migrate airborne research from large and costly platforms to smaller, more innovative platforms including commercial aircraft, and especially UAVs. Ames has been a leader in the applications of UAVs and this instrument would expand our lead role.

The resulting instrument would permit Ames to play a unique and valuable role in many Earth Observing System data calibration and validation experiments. It will also increase our contributions to the study of aerosol effects on Earth's climate sponsored by different agencies, a prime objective of the division.

If the envisioned instrument can be made light enough, it will be of high interest to UAV based research on Mars or other planets.

Present Status of Concept (i.e., initial idea, partially designed or analyzed concept, initial breadboard):

Using DDF funding, we currently address key technical challenges we encounter when designing the smaller, lighter, fully autonomous, more capable instrument described above. The challenges are:

a) Dynamic range of the detection system,

b) Suppression of unwanted stray light when measuring sky radiance a few degrees away from the Sun,

c) In-flight self-cleaning of the optical window.

Demonstrating solutions to all these challenges will enable us to finalize the mechanical, electrical and optical design of an instrument that can win more extensive funding from NASA HQ and other agencies to build and subsequently fly the completed instrument.

To this end we are developing a low-cost functional ground-based prototype system to address the technical challenges listed above. The prototype has azimuth and elevation motors and a quad sensor for accurate solar tracking or sky scanning (see Fig. 2 and Fig. 3). A Y-shaped fiber optics cable leads from two separate entrance optics, one for direct solar beam one for sky radiance (orange barrels in Fig. 2), to a rack-based Zeiss spectrometer. The rack also houses all non-moving parts such as power supply, motion controls, data acquisition PC, etc. The ground-based prototype instrument is currently about 80% complete.

In a NOAA funded activity, we are focusing on producing concepts and designs that address the issues of marrying smaller aircraft with smaller, lighter, lower-power, automated instruments. Our concepts include instruments that are both smaller and have more capabilities as compared to AATS-14. As in the DDF project, our miniaturization efforts are exploring the use of optical fibers with direct solar beam optics as a means of significantly reducing the size of the instrument and the size of the port required for its installation.

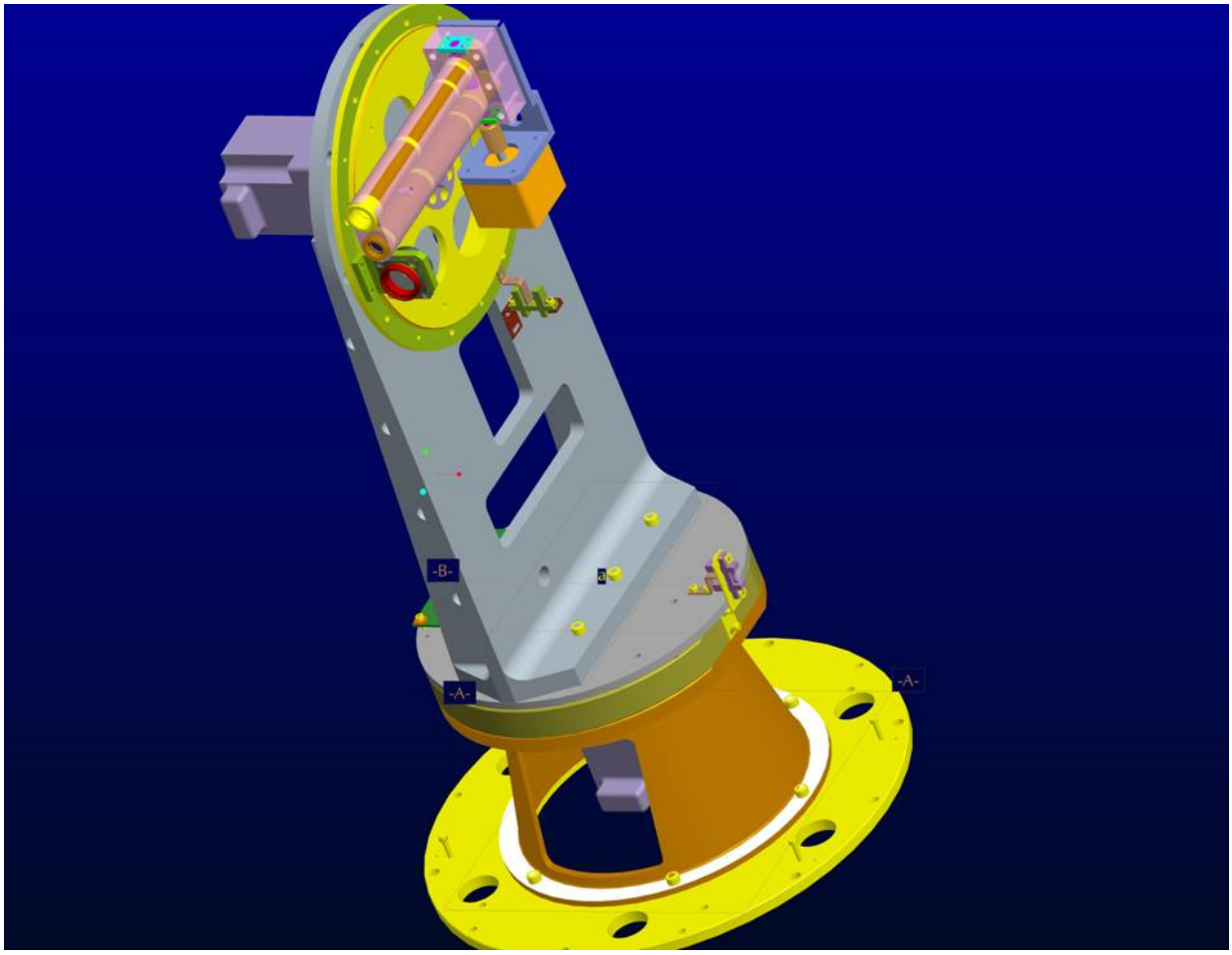

Fig 2: Pro-E model of ground-based prototype of proposed Autonomous Airborne Sun/Sky-Scanning Spectrometer.

Present Technology Readiness Level (TRL) (cf., http://www.hq.nasa.gov/office/codeq/trl/):
TRL = 6

What type of effort is needed to advance this idea to the next level? Identify design/analysis/review/costing activities, and estimate of needed skills?

Our current instrument development activities are carried out mostly by Nicholas Truong (Senior R&D engineer, BAER Inst.) and myself (PI, BAER Inst.), machine shop work was split 50/50 between Ames internal and external shops. According to the call, the IWG can only offer civil service labor support in FY06 and cannot provide money for procurements, travel, or PI/contractor labor.

Within these constraints IWG could best support the effort by providing time/funds for:

- Machine Shop Labor: 800 hours
- Electrical Technician: 800 hours
- Drafter/Designer (Pro-E): 1000 hours

What would be the end result of the next phase of work?

An airborne prototype version of the envisioned instrument. We are sure to have good opportunities for airborne demonstrations aboard CIRPAS or Sky Research aircraft.

Any relevant references or supporting documentation?

We have published data from our existing instruments in over 70 peer-reviewed publications. Information on our new instrument development can be found at http://geo.arc.nasa.gov/sgg/NID/

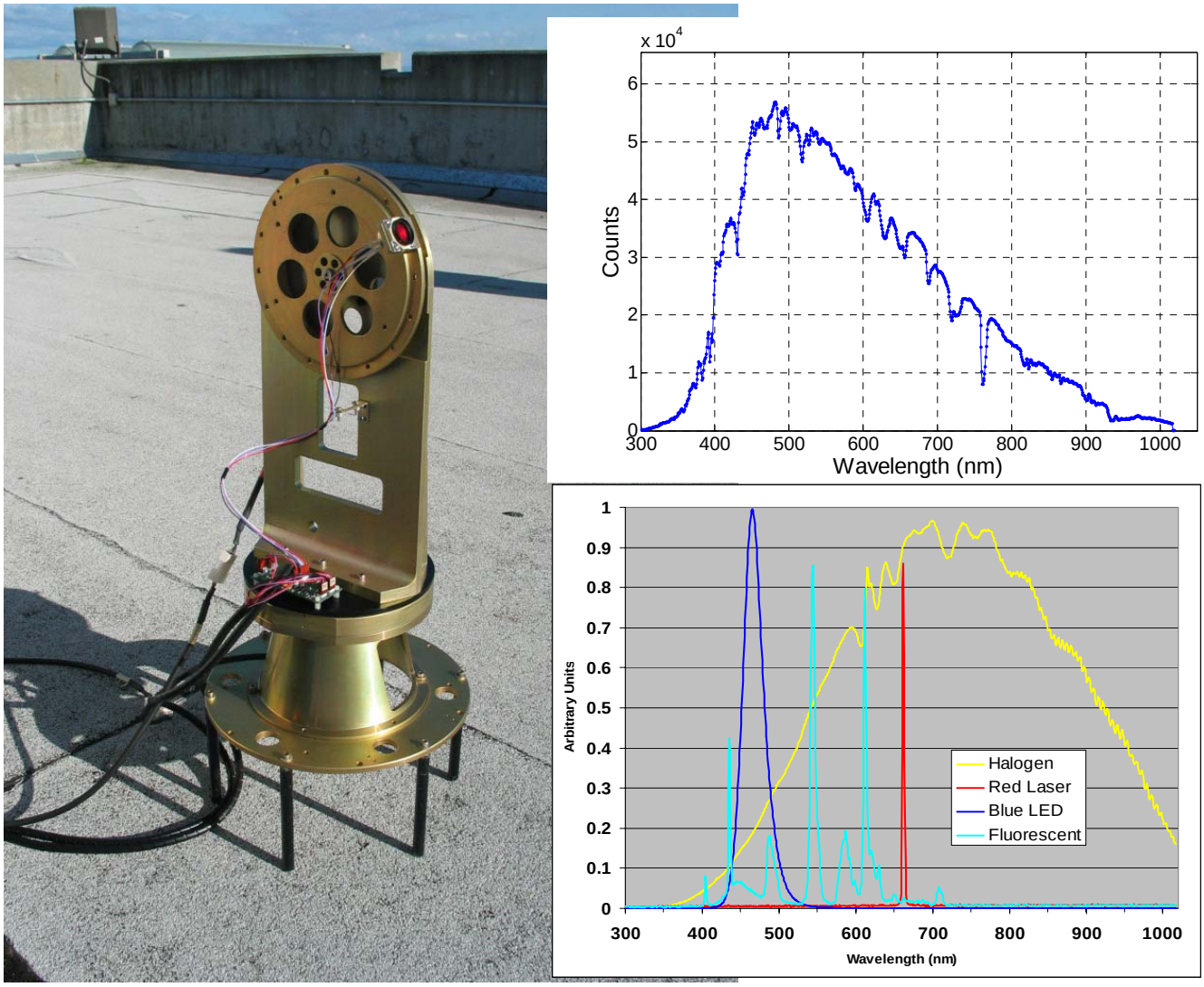

Fig. 3: Left: Ground-based prototype of Autonomous Airborne Sun/Sky-Scanning Spectrometer (without entrance optics). Top right: near-sun spectrum measured with Zeiss MMS spectrometer. Bottom right: Spectra of various artificial light sources measured with Zeiss MMS spectrometer.